CHAPTER

11

ELECTRICITY AND POWER SUPPLIES

In this chapter, you will learn:

- How electricity is measured
- How to measure the voltage output of the power supply
- How to change a power supply
- How a computer system can be protected from damaging changes in electrical power

Earlier chapters discussed most hardware components of the computer except the power supply, which provides the power to all other components inside the computer case. To troubleshoot problems with the power system of a PC, you need a basic understanding of electricity. This chapter begins by discussing how to measure electricity, and the form in which it comes to you as house current. The chapter then addresses the power supply, how to measure its output, and how to change a defective power supply. Lastly, the chapter considers backup power sources so that you understand what to look for when buying one to protect your computer system from electrical variations and outages.

Introduction to Basic Electricity

To most people, volts, ohms, watts, and amps are vague, ambiguous words that simply mean electricity. If these terms are mysterious to you, they will become clear in this section as electricity is discussed in nontechnical language, using simple analogies.

Electricity is energy; water is matter. However, the two have enough in common to make some analogies. Consider Figure 11-1. The water system shown in Part (a) is closed, that is, the amount of water in the system remains the same because no water enters and no water leaves the system. The electrical system in Part (b) is similar in several respects. Think of electricity as a stream of tiny charged particles (electrons) that flow like water along the path of least resistance.

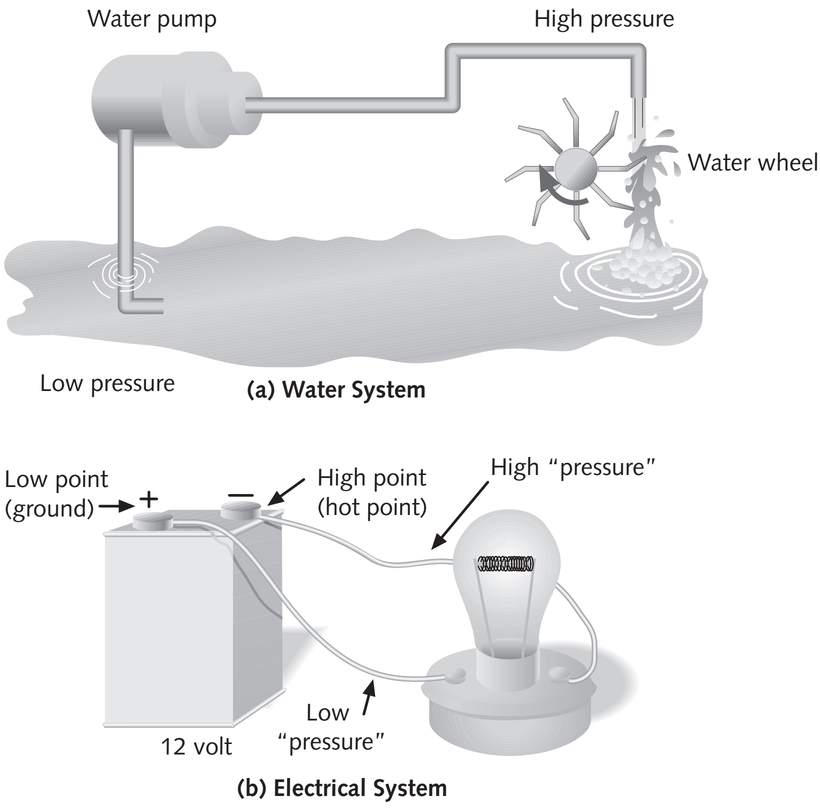

Figure 11-1 Two closed systems: a) water system with pump, wheel, and pool; b) electrical system with battery and light bulb

Water flows down because of the law of gravity, and electricity flows from negative to positive because of the law of like charges repelling one another. The water pump produces water pressure in the system by lifting the water, and a battery produces electrical pressure in the system by creating a buildup of negative charges in one location (in the form of electrons) that are driven to move. This difference in charge, which is similar to water pressure in a water system, is called potential difference. Water seeks a place of rest, moving from a high to a low elevation, and electrons seek a place of rest by moving from a negatively

charged location (called "hot") to a positively charged location (called "ground"). In the figure, as the water flows through the closed system, some of its force is harnessed by the water wheel and is converted to a form of energy, motion. Also in the figure, as the electrons flow in the closed electrical system, some of the force of the moving electrons is harnessed by the light bulb and converted to another form of energy, light. Once the water returns to the pool, water pressure decreases and the water is at rest, and, once the electrons arrive at the positive side of the battery, electrical potential difference decreases and the system is at rest.

TIP

When speaking of electron flow, the flow is from the hot point or negative terminal to the ground or positive terminal. Because early theories of electricity assumed that electricity flowed from positive to negative, most electronics books show the current flow from positive to negative. This method is called conventional current flow and, if it were used in Figure 11-1, the positive and negative symbols would be reversed in the figure.

Electricity is energy that has properties that can be measured in various ways. The description above (of an electrical system that includes a battery and a light bulb) illustrates some simple principles of how electricity works that apply to the most complex electrical systems. We next use this simple electrical system to define four properties of electricity, all of which can be measured (see Table 11-1).

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Table 11-1 The measures of electricity

Unit	Definition	An Example as Applied to a Computer
Volts (measures potential difference)	Abbreviated as V (for example, 110 V). Volts are measured by finding the potential difference between the electrical charges on either side of an electrical device in an electrical system.	An AT power supply supplies four separate voltages: +12 V, -12 V, +5 V, -5 V. An ATX power supply supplies these and also 3.3 V.
Amps or Amperes (measures electrical current)	Abbreviated as A (for example, 1.5 A). Amps are measured by placing an ammeter in the flow of current and measuring that current.	A 17-inch monitor requires less than 2 A to operate. A small laser printer uses about 2 A. A CD-ROM drive uses about 1 A.
Ohms (measures resistance)	Abbreviated with the symbol Ω (for example, 20 Ω). Devices are rated according to how much resistance they offer to electrical current. The ohm rating of a resistor or other electrical device is often written somewhere on the device. The resistance of a device is measured when the device is not connected to an electrical system.	Current can flow in typical computer cables and wires with a resistance of less than 20 ohms. This condition of low resistance that allows current to flow is called **continuity**.
Watts (measures power)	Abbreviated W (for example, 20 W). Watts are calculated by multiplying volts by amps.	A computer power supply is rated at 200 to 600 watts.

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Voltage

The first measure of electricity listed in Table 11-1 is potential difference. First consider how to measure the water pressure. If you measure the pressure of the water directly above the water wheel, and then measure the pressure just as the water lands in the pool, you find that the water pressure above the wheel is greater than the water pressure below it.

Now consider the electrical system. If you measure the electrical charge on one side of the light bulb and compare it to the electrical charge on the other side of the bulb, you see a difference in charge. The potential difference in charge creates an electrical force that drives the electrons through the system between two points, and is called **voltage**, which is measured in units called **volts**.

In Figure 11-2, the leads of a **voltmeter**, a device for measuring electrical voltage, are placed on either side of a light bulb that is consuming some electrical power. The potential difference between the two points on either side of the device is the voltage in the closed system. Voltage is measured when the power is on.

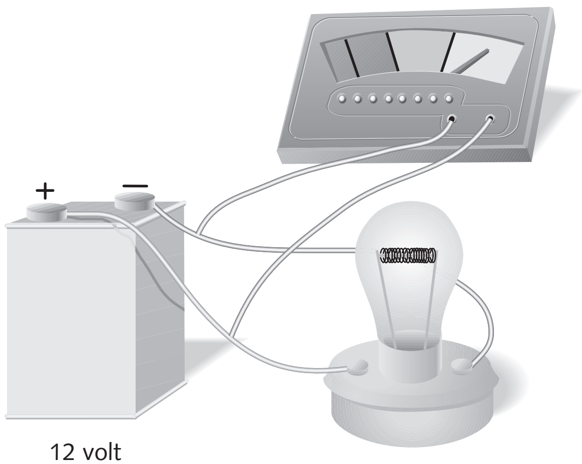

Figure 11-2 A voltmeter measuring the voltage across a bulb and a battery

Amps

The volume of electrons (or electricity) flowing through an electrical system is called current. Look back at Figure 11-1. The volume or amount of water flowing through the water system does not change although the water pressure changes at different points in the system. To measure that volume, you pick one point in the system and measure the volume of water that passes through that point over a period of time. The electrical system is similar. If you measure the number of electrons, or electrical current, at any point in this system, you find the same value as at any other point because the current is constant throughout the system. (This assumes that there is only a single pipe or a single wire in the entire closed water or electrical system.) Electrical current is measured in **amperes**, abbreviated **amps**. Figure 11-3 shows the measuring device called an **ammeter**, which measures electrical current in amps. You

place the ammeter in the path of the electrical flow so that the electrons must flow through the ammeter. The measurement is taken with the power on and might not be completely accurate because the ammeter can influence the circuit.

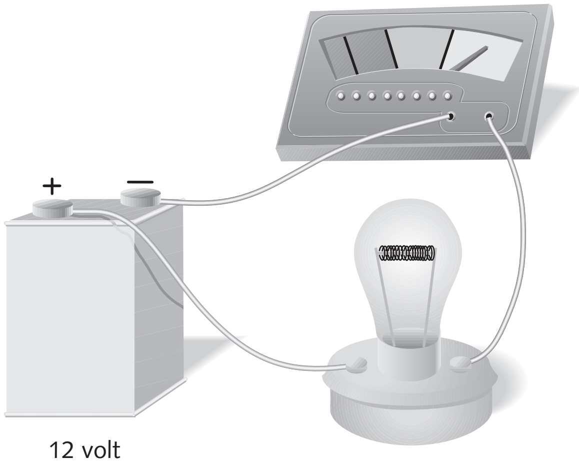

Figure 11-3 Battery and bulb circuit with ammeter in line

> TIP: Because the current flows through an ammeter, check the rating of the ammeter before measuring amps to make sure it can handle the flow of electricity. More flow than the ammeter is designed to handle can blow the meter's fuse.

The Relationship Between Voltage and Current

Refer again to the water system in Figure 11-1. To increase the volume of water flowing through the system, you increase the difference in water pressures between the low and high points (which is referred to as the pressure differential). As the pressure differential increases, the water flow or current increases, and as the water pressure differential decreases, the water flow or current decreases. Another way of saying this is: there is a direct relationship between pressure differential and current. An electrical system has the same relationship. As the electrical potential difference (or voltage) increases, the electrical current increases; as the voltage decreases, the current decreases. There is a direct relationship between voltage and current.

Ohms

Suppose you are working your water pump to full capacity. If you still want to increase the overall power of your water system so the wheel turns faster to produce more mechanical energy, you can decrease the resistance to water flow, which allows more water to flow to push the wheel faster. You might use a larger pipe, a lighter water wheel, or, if the system has a partially open water valve, you can open the valve more, all of which would lower resistance to water flow. As resistance decreases, current increases. As resistance increases (smaller pipes, heavier wheel, partially closed valve), current decreases.

Similarly, **resistance** in an electrical system is a property that opposes the flow of electricity. As the electrical resistance increases, the electricity decreases. As the resistance decreases, the electricity increases. When there is more resistance to the flow of electricity, the flow of electrons decreases. Also, when too much electricity flows through a wire, heat energy is created in the wire (similar to friction). This heat energy can cause the wire to melt or burn, which can result in an electrical fire, just as too much water current in a pipe can cause it to burst. Reducing the size of a wire reduces the amount of electricity that can safely flow through. Electrical resistance is measured in **ohms**.

Resistors are devices used in electrical circuits to resist the flow of electricity. (Sorry, I couldn't resist saying that!) Resistors control the flow of electricity in a circuit, much as partially closed valves control the flow of water.

Relationships Among Voltage, Current, and Resistance

Voltage and current have a *direct* relationship. This means that when voltage increases, current increases. Resistance has an *inverse* relationship between voltage and current. This means that as resistance increases, either current or voltage decreases. As resistance decreases, either current or voltage increases. This last statement is known as Ohm's Law. A similar statement defines the relationship among the units of measure—volts, amps, and ohms. One volt drives a current of one amp through a resistance of one ohm.

Wattage

Our discussion of electricity would not be complete without covering one last measure of electricity. **Wattage** is the total amount of power needed to operate an electrical device. When thinking of the water system, you recognize that the amount of water power used to turn the water wheel is not just a measure of the water pressure that forces current through the system. The amount of power is also related to the amount of water available to flow. For a given water pressure, you have more power with more water flow and less power with less water flow. A lot of power results when you have a lot of pressure and a lot of current.

As with the water system, electrical power increases as both voltage and current increase. Wattage, measured in **watts**, is calculated by multiplying volts by amps in a system.

AC and DC Current

Electricity can be either AC, alternating current, or DC, direct current. **Alternating current** (**AC**) is current that cycles or oscillates back and forth rather than traveling in only one direction. House current in the U.S. oscillates 60 times in one second (60 hertz), changing polarity from +110V to –110V, and causing current to flow in different directions depending on whether it's positive or negative in the cycle. AC current is the most economical way to transmit electricity to our homes and workplaces. Alternating current can be forced to travel great distances by decreasing current and increasing voltage (high pressure and low volume). When it reaches its destination, the voltage can be decreased and the current increased (low pressure and high volume) to make it more suitable for driving our electrical devices.

Direct current (**DC**) travels in only one direction and is the type of current required by most electronic devices, including a computer. A **rectifier** is a device that converts alternating current to direct current. A **transformer** is a device that changes the ratio of current to voltage. Large transformers are used to reduce the high voltage on power lines coming to your neighborhood to a lower voltage before entering your home. Because the transformer does not change the amount of power in this closed system, if it decreases voltage, then it increases current. The overall power stays constant, but the ratio of voltage to current changes.

A computer power supply changes and conditions the house electrical current in several ways, functioning as both a transformer and a rectifier (see Figure 11-4). It steps down the voltage from the 110-volt house current to 3.3, 5, and 12 volts or to 5 and 12 volts, and changes incoming alternating current to direct current, which the computer and its peripherals require. The monitor, however, receives the full 110 volts of AC current, converting that current to DC.

Recall that direct current flows in only one direction, from hot to ground. For a PC, a line may be either +5 or –5 volts in one circuit, or +12 or –12 volts in another circuit, depending on whether the circuit is on the far or near end of the power output (the hot point). Several circuits coming from the power supply accommodate different devices with different power requirements.

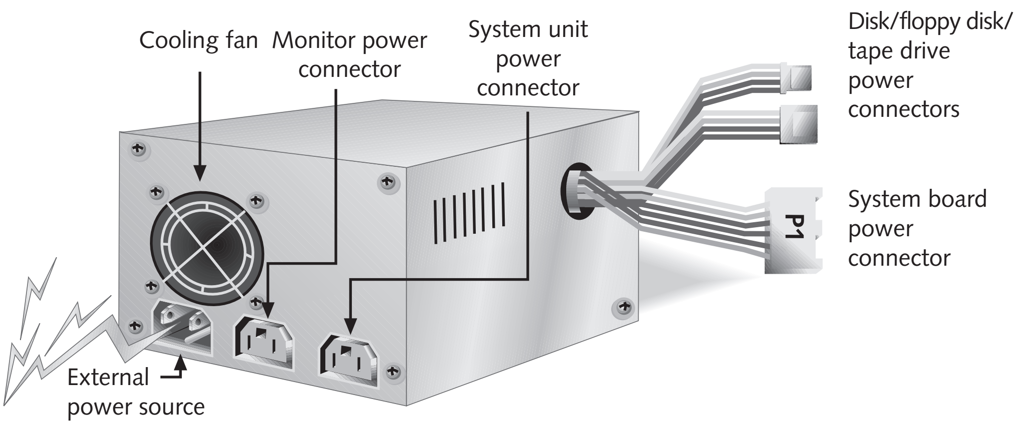

Figure 11-4 ATX power supply with connections

Hot, Neutral, and Ground

When AC current comes from the power station to your house, it travels from the power source at the power station to your house on a hot line and completes the circuit from your house back to the power source on a neutral line, as seen in Figure 11-5. When the two lines get to your house and enter an electrical device, such as a lamp or radio, the electricity flows through the device to complete the circuit between the hot line and the neutral line. The device contains resistors and other electrical components that control the flow of electricity between the hot and neutral lines. The hot source is seeking ground and finds that by returning to the power station on the neutral line.

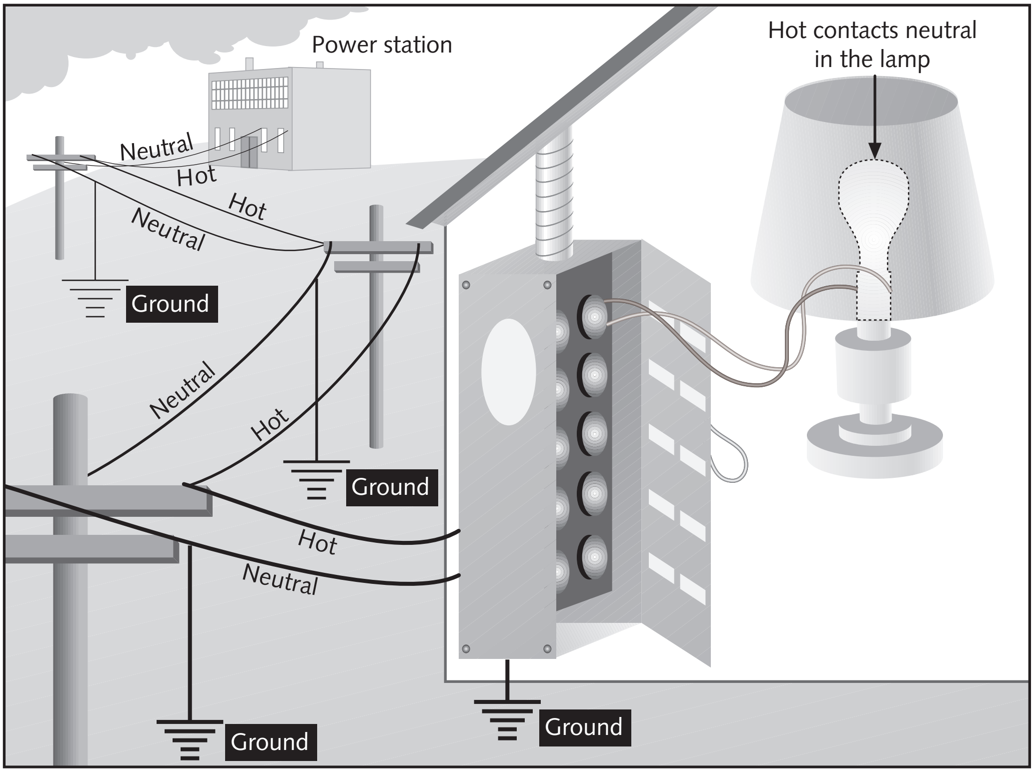

Figure 11-5 Normally hot contacts neutral to make a closed circuit in the controlled environment of an electrical device such as a lamp. An out-of-control contact is called a short, and the flow of electricity is then diverted to the ground.

A short circuit, or a short, occurs when the electricity is allowed to flow uncontrolled from the hot line to the neutral line or from the hot line to ground. Electricity naturally finds the easiest route to ground. Normally that path is through some device that is controlling the current flow and then back through the neutral line. If an easier path (one with less resistance) is available, the electricity follows that path. This can cause a short, a sudden increase in flow that can create a sudden increase in temperature, which can start a fire and injure both people and equipment. Never put yourself in a position where you are the path of least resistance between the hot line and ground!

A fuse is a component included in a circuit and designed to prevent too much current from flowing through the circuit. A fuse is commonly a wire inside a protective case, which is rated in amps. If too much current begins to flow, the wire gets hot and eventually melts, breaking the circuit and stopping the current flow. Many devices have fuses, which can be easily replaced when damaged. You will learn to test a fuse later in the chapter.

To prevent the uncontrolled flow of electricity from continuing indefinitely, which can happen because of a short, the neutral line is grounded. Grounding a line means that the line is connected directly to the earth so that, in the event of a short, the electricity flows into the

earth and not back to the power station. The grounding serves as an escape route for out-of-control electricity. The earth is considered to be at no particular state of charge and always capable of accepting a flow of current.

The neutral line to your house is grounded many times along the way (in fact at each electrical pole) and is also grounded at the breaker box where the electricity enters your house. You can look at a three-prong plug and see the three lines, hot, neutral, and ground (see Figure 11-6). Generally, electricians use green or bare wire for the ground wire, white for neutral, and black for hot in home wiring for 110 volt circuits. In a 220-volt circuit, black and red are hot, white is neutral, and green or bare is ground. To verify that a wall outlet is wired correctly, use a simple receptacle tester as shown in Figure 11-7.

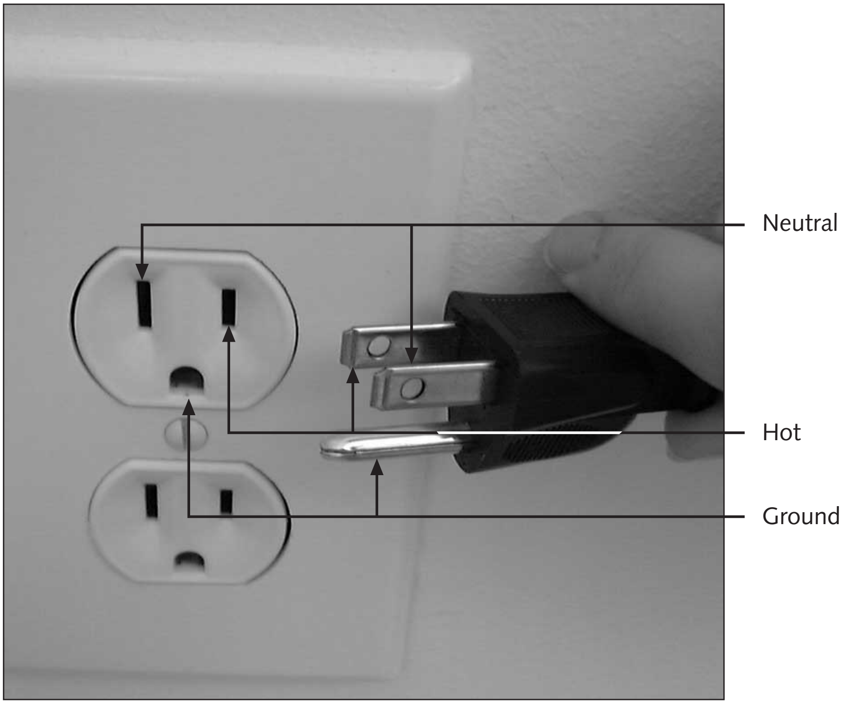

Figure 11-6 A three-prong plug showing hot, neutral, and ground

TIP

Beware of the different uses of black wire. In PCs, black is used for ground, but in home wiring, black is used for hot!

Figure 11-7 Use a receptacle tester to verify hot, neutral, and ground are wired correctly

It's very important that PC components be properly grounded. Never connect a PC to an outlet or use an extension cord that doesn't have the third ground plug. The third line can prevent a short from causing extreme damage. In addition, the bond between the neutral and ground also helps eliminate electrical noise (stray electrical signals) within the PC sometimes caused by other electrical equipment sitting very close to the computer. This electomagnetic interference is covered later in the chapter.

> TIP
> Even though you might have a three-prong outlet in your home, the ground plug might not be properly grounded. To know for sure, test the outlet with an inexpensive outlet tester.

Some Common Electronic Components

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A PC contains many electronic components. It's interesting to understand what basic electronic components make up a PC and how they work. Basic electrical components in a PC include transistors, capacitors, diodes, and resistors. Figure 11-8 shows the symbols for these four components. Materials used to make these and other electrical components can be:

- **Conductors**. Material that easily conducts electricity such as gold or copper
- **Insulators**. Material that resists the flow of electricity such as glass or ceramic
- **Semiconductors**. Material such as silicon with an ability to conduct electricity that falls between that of conductors and insulators

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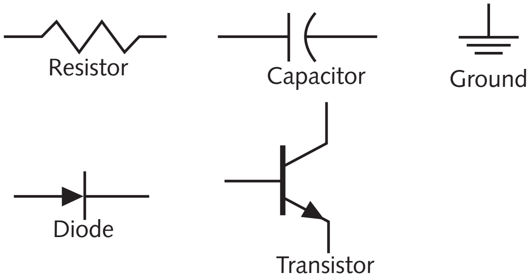

Figure 11-8 Symbols for some electronic components and ground

A **transistor** is an electronic device that can serve as a gate or switch for an electrical signal and can amplify the flow of electricity. Invented in 1947, the transistor is made of three layers of semiconductor material. A charge (either positive or negative, depending on how the transistor was designed) placed on the center layer can cause the two outer layers of the transistor to complete a circuit to create an "on" state. An opposite charge placed on the center layer can cause the reverse to happen, causing the transistor to create an "off" state. By manipulating these charges to the transistor, it can be used to hold a logic state, either on or off (translated to 0 or 1 in binary). When the transistor is maintaining this state, it requires almost no electrical power. Because the initial charge sent to the transistor is not as great as the resulting current created by the transistor, sometimes a transistor is used as a small amplifier. The transistor is the basic building block of an integrated circuit (IC) that is used to build a microchip.

A **capacitor** is an electronic device that can hold an electrical charge for a period of time and is used to smooth out the uneven flow of electricity through a circuit. Capacitors inside a PC power supply create the even flow of current needed by the PC. Capacitors maintain their charge long after current is no longer present, which is why the inside of a power supply can be dangerous even when it is unplugged.

A **diode** is a semiconductor device that allows electricity to flow in only one direction. (A transistor contains two diodes.) One to four diodes used in various configurations can be used to convert the AC to DC. Singularly or collectively, depending on the configuration, these diodes are called a rectifier.

As explained above, a resistor is an electronic device that limits the amount of current that can flow through it.

ESD and EMI

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Recall that ESD (electrostatic discharge) is a brief flow of electricity caused by two objects that have a difference in voltage potential coming in contact with one another. Now that you better understand the concept of grounding, you can see why it is important that you be grounded before you work with computer components. If both you and the component

A+CORE 3.2, 2.1

you are going to work with are grounded, then there will be no potential voltage difference between you and the component, and no electrical discharge will occur when you touch it.

There are exceptions to the rule of always being grounded when you work with PCs. You *don't* want to be grounded when working inside a monitor or with a power supply. These devices maintain high charges of electricity, even when the power is turned off. *Don't* wear a ground bracelet when working inside these devices, because you don't want to be the ground for these charges!

Another problem with computers that can be caused by electricity is **electromagnetic interference** (**EMI**). EMI is caused by the magnetic field that is produced as a side effect when electricity flows. EMI in the radio frequency range is called radio frequency interference (RFI), which can cause problems with the radio and TV reception. Data in data cables that cross this magnetic field can become corrupted, which is called crosstalk. Crosstalk is partly controlled by using shielded data cables covered with a protective material. Power supplies are also shielded to prevent them from emitting EMI. PCs can also emit EMI to other nearby PCs, which is one reason a computer needs to be inside a case, and the case should not have holes—so always install face plates in empty drive bays or over empty expansion slots.

If a PC persists in giving mysterious, intermittent errors, one thing to suspect is EMI. Try moving the PC to a new location. If the problem persists, try moving it to a location that uses an entirely different electric circuit. One simple way to detect the presence of EMI is to use a small inexpensive AM radio. Turn the tuning dial away from a station into a low-frequency range. With the radio on, you can hear the static produced by EMI. Try putting the radio next to several electronic devices to detect the EMI they emit.

If EMI in the electrical circuits coming to the PC is a significant problem, you can use a line conditioner that filters out the electrical noise causing the EMI. Line conditioners are discussed later in the chapter.

MEASURING THE VOLTAGE OF A POWER SUPPLY

If you suspect a problem with a power supply, one thing you can do is measure the voltage output. When a power supply is working properly, voltages all fall within an acceptable range (plus or minus 10%). However, be aware that even if measured voltage is within the appropriate range, a power supply can still cause problems. This is because problems with power supplies often come and go. Therefore, if the voltages are correct, you should still suspect the power supply to be the problem when certain symptoms are present. To learn for certain whether the power supply is the problem, replace it with a unit you know is good.

Using a Multimeter

A+CORE 2.1

A voltmeter measures the difference in electrical potential between two points in volts, and an ammeter measures electrical current in amps. Figure 11-9 shows a **multimeter**, which can be used as either a voltmeter or an ammeter, or can measure resistance or continuity (the presence of a complete circuit), depending on a dial or function switch setting. Less expensive multimeters commonly measure voltage, resistance, and continuity, but not amps.

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Measure voltage and amps while the electricity is on. Measure resistance and continuity while the electricity is off. For the specific details of how to use your multimeter, consult the manual, which explains what you can measure with the multimeter and how to use it.

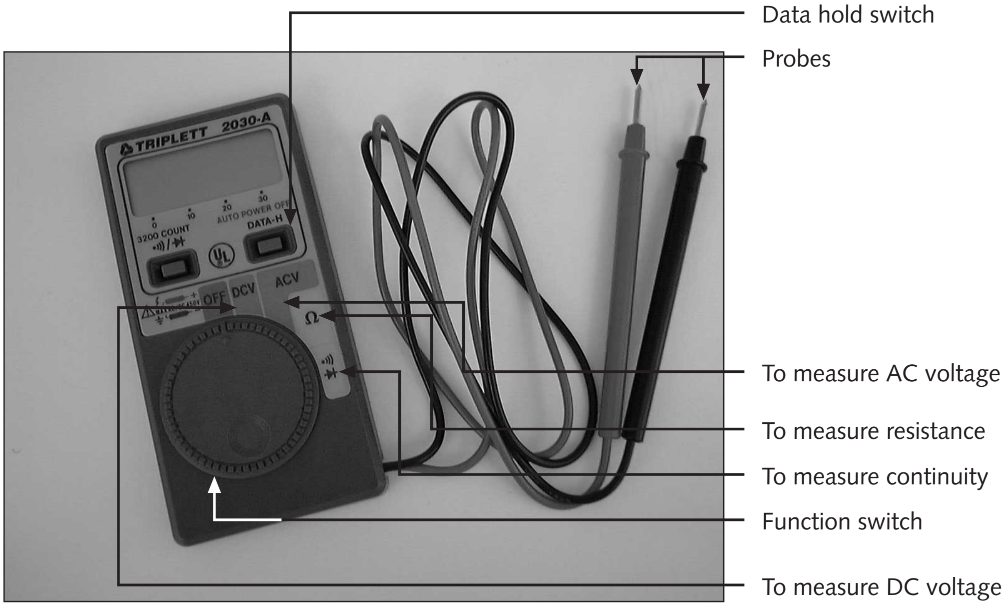

Figure 11-9 A digital multimeter

A multimeter can provide either a digital or an analog display. A digital display shows the readings as digits displayed on an LCD (liquid crystal display) panel. A digital multimeter is sometimes called a DMM (digital multimeter) or a DVM (digital voltage meter). An analog display shows the readings as a needle moving across a scale of values. Multimeters are sometimes small portable battery-powered units. Larger ones are designed to sit on a countertop and are powered by a wall outlet.

When you use a multimeter, you must tell it three things before you begin: (1) what you want it to measure (voltage, current, or resistance), (2) whether the current is AC or DC, and (3) what range of values it should expect. If you are measuring the voltage output from a wall outlet (110–120 V), the range should be much higher than when measuring the voltage output of a computer power supply (3-12 V). Setting the range high assures you that the meter can handle a large input without pegging the needle (exceeding the highest value that the meter is designed to measure) or damaging the meter. However, if you set the range too high, you might not see the voltage register at all. Set the range low enough to assure you that the measure is as accurate as you need, but not so low as to be less than the expected voltage. When you set the range too low on some digital multimeters, the meter reads OL on the display.

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For example, to measure the voltage of house current, if you expect the voltage to be 115 volts, set the voltage range from 0 to somewhere between 120 and 130 volts. You want the high end of the range to be slightly higher than the expected voltage. Most meters do not allow a very large voltage or current into the meter when the range is set low to protect the meter. Some multimeters are **autorange meters**, which sense the quantity of input and set the range accordingly.

A meter comes with two test probes. One is usually red and the other black. Install the red probe at the positive (+) jack on the meter and the black probe at the negative (–) jack.

To measure voltage, place the other end of the black probe at the ground point and the other end of the red probe at the hot point, without disconnecting anything in the circuit and with the power on. For example, to measure voltage using the multimeter in Figure 11-9, turn the function switch dial to DCV for DC voltage measurement. This meter is autoranging, so this is all that needs to be set. With the power on, place the two probes in position and read the voltage from the LCD panel. The DATA-H switch (data hold) allows you to freeze the displayed reading.

To measure current in amps, as in Figure 11-3, the multimeter itself must be part of the circuit. Disconnect the circuit at some point so that you can connect the multimeter in line to find a measure in amps. Not all multimeters can measure amps.

You can also use a multimeter to measure continuity, which indicates if there is little or no resistance (less than 20 ohms gives continuity in a PC) in a wire or a closed connection between two points, meaning that the path for electricity between the two points is unhindered or "continuous." This measurement is taken with no electricity present in the circuit.

For example, if you want to know that pin 2 on one end of a serial cable is connected to pin 3 on the other end of the cable, set the multimeter to measure continuity, and work without the cable being connected to anything. Put one probe on pin 2 at one end of the cable and the other probe on pin 3 at the other end. If the two pins connect, the multimeter indicates this with a reading on the LCD panel, or a buzzer sounds (see the multimeter documentation). In this situation, you might find that the probe is too large to extend into the pinhole of the female connection of the cable. A straightened small paper clip works well here to extend the probe. However, be very careful not to use a paper clip that is too thick and might widen the size of the pinhole, which can later prevent the pinhole from making a good connection.

To determine if a fuse is good, you actually measure continuity. With a multimeter set to measure continuity, place its probes on each end of the fuse. If the fuse has continuity, then it is good. If the multimeter does not have a continuity setting, set it to measure resistance. If the reading in ohms is approximately zero, there is no resistance and the fuse is good. If the reading is infinity, there is infinite resistance and the fuse is blown and should not be used.

How to Measure the Voltage of a Power Supply

To determine that a power supply is working properly, measure the voltage of each circuit supported by the power supply. First open the computer case and identify all power cords coming from the power supply. Look for the cords from the power supply to the system board

and other power cords to the drives. Follow the directions described in the next section to measure the voltage of the power supply output to the system board (see Figure 11-10).

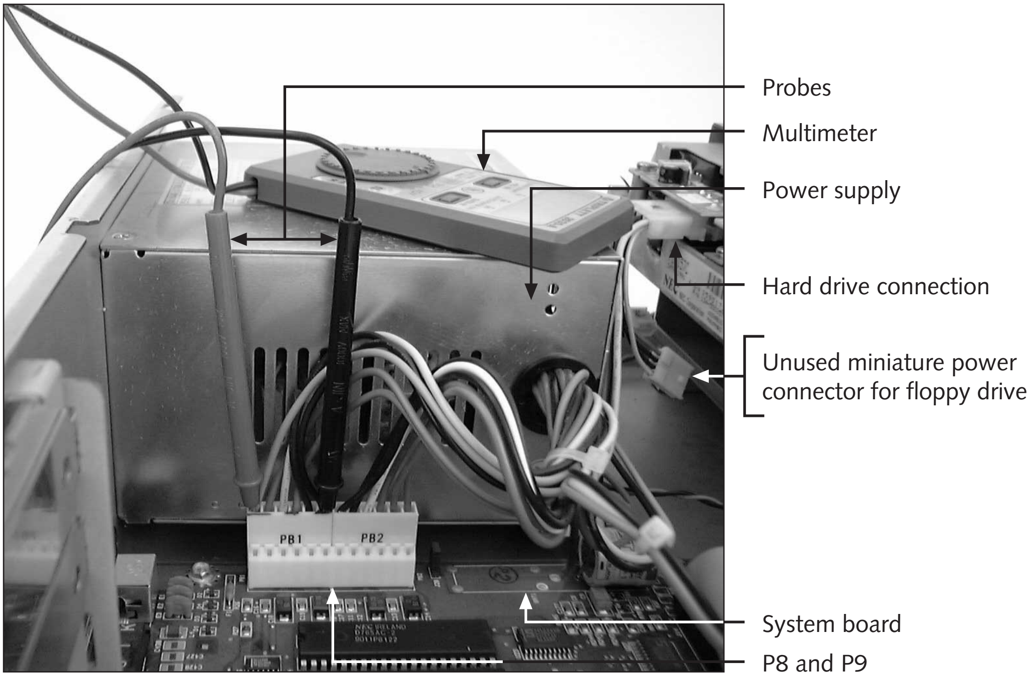

Figure 11-10 Multimeter measuring voltage on an AT system board

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Testing the Power Output of the Power Supply

The computer must be turned on to test the power supply output. Be very careful not to touch any chips or disturb any circuit boards as you work. The voltage output from the power supply is no more than 14 volts, which is not enough to seriously hurt you if you accidentally touch a hot probe. However, you can damage the computer if you are not careful.

You can hurt yourself if you accidentally create a short circuit from the power supply to ground through the probe. If you touch the probe to the hot circuit and also to ground, the current is diverted from the computer circuit and through the probe to ground. This short might be enough to cause a spark or to melt the probe, which can happen if you allow the two probes to touch each other while one of them is attached to the hot circuit and the other is attached to ground. Make *sure* the probes only touch one metal object, preferably only a single power pin on a connector, or you could cause a short.

Because of the danger of touching a hot probe to a ground probe, you might prefer not to put the black probe into a ground lead that is too close to the hot probe. Instead, when the directions say to place the black probe on a lead that is very close to the hot probe, you can use a black wire lead on an unused power supply connection meant for a hard drive. The idea is that the black probe should always be placed on a ground or black lead.

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All ground leads are considered at ground, no matter what number is assigned that lead. Therefore, you can consider all black leads to be equal. For an AT system board, the ground leads for P8 and P9 are the four black center leads 5, 6, 7, and 8. For an ATX system board, the ground leads are seven black leads in center positions on the ATX P1 power connector. The ground leads for a hard drive power connection are the two black center leads, 2 and 3.

We first discuss how to measure the power output for AT and ATX system boards and then for a secondary storage device.

Measuring Voltage Output to an AT System Board

1. Remove the cover of the computer. The voltage range for each connection is often written on the top of the power supply. The two power connections to the system board are often labeled P8 and P9. Figure 11-11 shows a closeup of the two connections, P8 and P9, coming from the power supply to the system board. Each connection has six leads, for a total of 12 leads. Of these 12, four are ground connections, and lead 1 is a "power good" pin, used to indicate that the system board is receiving power. A common arrangement for these 12 leads is listed in Table 11-2.

Table 11-2 Twelve leads to the AT system board from the AT power supply

Connection	Lead	Description	Acceptable Range
P8	1	"Power Good"	
	2	Not used or +5 volts	+4.4 to +5.2 volts
	3	+12 volts	+10.8 to +13.2 volts
	4	–12 volts	–10.8 to –13.2 volts
	5	Black ground	
	6	Black ground	
P9	7	Black ground	
	8	Black ground	
	9	–5 volts	–4.5 to –5.5 volts
	10	+5 volts	+4.5 to +5.5 volts
	11	+5 volts	+4.5 to +5.5 volts
	12	+5 volts	+4.5 to +5.5 volts

A+ CORE 2.1

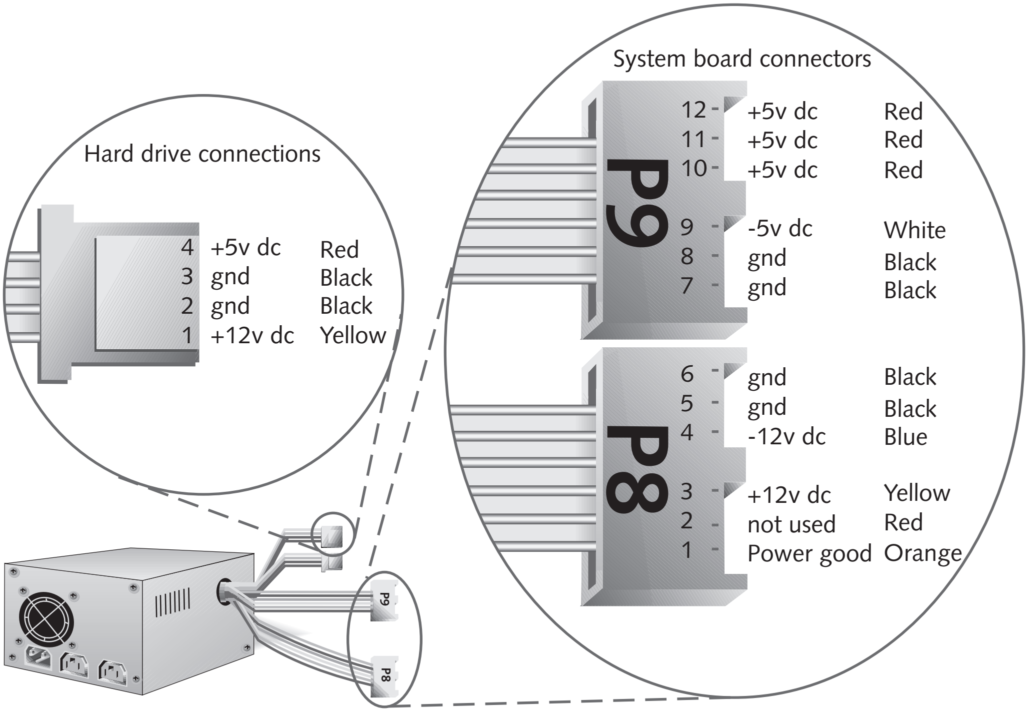

Figure 11-11 AT power supply connections

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2. Set the multimeter to measure voltage in a range of 20 volts and set the AC/DC switch to DC. Insert the black probe into the – jack and the red probe into the + jack of the meter.
3. Turn on the multimeter, and turn on the computer.
4. To measure the +12-volt circuit and all four ground leads:
   - Place the red probe on lead 3. The probe is shaped like a needle (alligator clips don't work too well here); insert the needle down into the lead housing as far as you can. Place the black probe on lead 5. The acceptable range is +10.8 to +13.2 volts.
   - Place the red probe on lead 3, and place the black probe on lead 6. The acceptable range is +10.8 to +13.2 volts.
   - Place the red probe on lead 3, and place the black probe on lead 7. The acceptable range is +10.8 to +13.2 volts.
   - Place the red probe on lead 3, and place the black probe on lead 8. The acceptable range is +10.8 to +13.2 volts.
5. To measure the –12-volt circuit, place the red probe on lead 4, and place the black probe on any ground lead or on the computer case, which is also grounded. The acceptable range is –10.8 to 13.2 volts.

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6. To measure the –5-volt circuit, place the red probe on lead 9, and place the black probe on any ground. The acceptable range is –4.5 to –5.5 volts.
7. To measure the three +5-volt circuits:
   - Place the red probe on lead 10, and place the black probe on any ground. The acceptable range is +4.5 to +5.5 volts.
   - Place the red probe on lead 11, and place the black probe on any ground. The acceptable range is +4.5 to +5.5 volts.
   - Place the red probe on lead 12, and place the black probe on any ground. The acceptable range is +4.5 to +5.5 volts.
8. Replace the cover.

Measuring Voltage Output to an ATX System Board

To measure the output to the ATX system board, follow the same procedure as with the AT system board. Recall that the ATX board uses 3.3, 5, and 12 volts coming from the power supply. Figure 11-12 shows the power output of each pin on the connector. Looking at Figure 11-12, you can see the distinguishing shape of each side of the connector. Notice the different hole sizes on each side of the connector, ensuring that the plug from the power supply is oriented correctly in the connector. Table 11-3 lists the leads to the system board and their acceptable voltage ranges.

Table 11-3 Twenty leads to the ATX system board from the ATX power supply

Unnotched Side			Notched Side		
Lead	**Description**	**Acceptable Range**	**Lead**	**Description**	**Acceptable Range (volts)**
1	+12 volts	+10.8 to +13.2	1	+5 volts	+4.5 to +5.5
2	+5 volts standby	+4.5 to +5.5	2	+5 volts	+4.5 to +5.5
3	"Power good"		3	–5 volts	–4.5 to –5.5
4	Black ground		4	Black ground	
5	+5 volts	+4.5 to +5.5	5	Black ground	
6	Black ground		6	Black ground	
7	+5 volts	+4.5 to +5.5	7	Pwr supply on	
8	Black ground		8	Black ground	
9	+3.3 volts	+3.1 to +3.5	9	–12 volts	–10.8 to –13.2
10	+3.3 volts	+3.1 to +3.5	10	+3.3 volts	+3.1 to +3.5

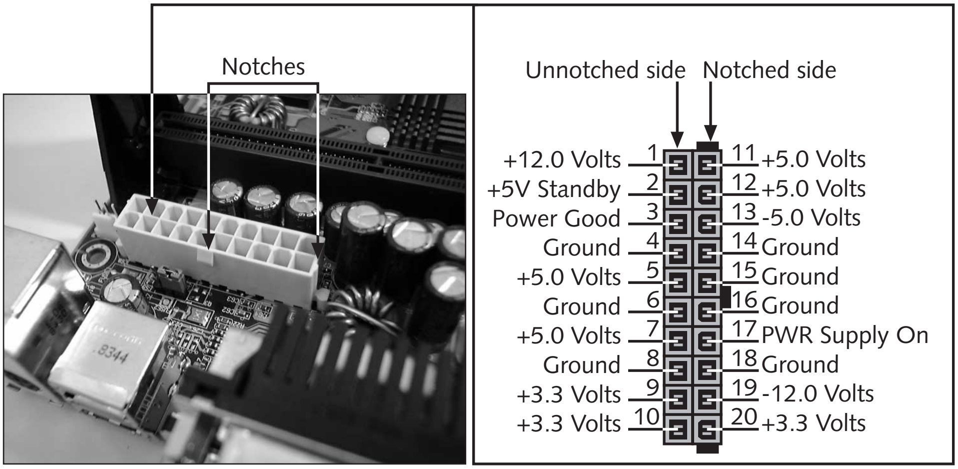

Figure 11-12 Power connection on an ATX system board

Testing the Power Output to a Floppy or Hard Drive

The power cords to the floppy disk drive, hard drive, and CD-ROM drive all supply the same voltage: one +5-volt circuit and one +12-volt circuit. The power connection to any drive uses four leads; the two outside connections are hot, and the two inside connections are ground (see Figure 11-11). The power connection to a 3.5-inch floppy disk drive is usually a miniature connection, as shown in Figure 11-10. Follow these steps to measure the voltage to any drive:

1. With the drive plugged in, turn the computer on.
2. Set the multimeter to measure voltage as described above.
3. Place the red probe on lead 1 shown in Figure 11-11, and place the black probe on lead 2 or 3 (ground). The acceptable range is +10.8 to +13.2 volts.
4. Place the red probe on lead 4, and place the black probe on lead 2 or 3 (ground). The acceptable range is +4.5 to +5.5 volts.

You may choose to alter the method you use to ground the black probe. In Step 4 above, the red probe and black probe are very close to each other. You may choose to keep them farther apart by placing the black probe in a ground lead of an unused hard drive connection.

Problems with the Power Supply

If you assemble a PC from parts, most often you purchase a computer case with the power supply already installed in it. However, you might need to exchange the present power supply because it is damaged, or because you need to upgrade to one with more power. In this section, you will learn how to detect a faulty power supply and how to exchange one.

Power Supplies Can Be Dangerous

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The power supply has capacitors inside it, which hold their electrical charge even after the power is disconnected. Never open the case of the power supply unless you have been trained how to protect yourself from high-voltage equipment.

TIP

If you do open the case to work inside the power supply itself, don't wear your anti-static bracelet. Recall that the bracelet grounds you, and you don't want to be a ground for the high voltage (110 to 120 volts) of the power supply!

Power Supply Troubleshooting Guidelines

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Problems with the PC's power supply or the house current can express themselves in the following ways:

- The PC sometimes halts during booting. After several tries, it boots successfully.
- Error codes or beep codes occur during booting, but the errors come and go.
- The computer stops or hangs for no reason. Sometimes it might even reboot itself.
- Memory errors appear intermittently.
- Data is written incorrectly to the hard drive.
- The keyboard stops working at odd times.
- The system board fails or is damaged.
- The power supply overheats and becomes hot to the touch.

An overheated system can cause intermittent problems. Use compressed air to blow the dust out of the power supply and the vents over the entire computer. Dust acts like an insulator and retains heat inside the computer case. Check that the power supply fan and the fan over the CPU are both working.

The symptoms of electrical power problems might be caused by a brownout (reduced current) of the house current or by a faulty power supply. If you suspect that the house current could be low, check the other devices that are using the same circuit. A copy machine, laser printer, or other heavy equipment might be drawing too much power. Remove the other devices from the same house circuit.

A system with a standard power supply of about 250 watts that has multiple hard drives, multiple CD-ROM drives, and several expansion cards is most likely operating above the rated capacity of the power supply, which can cause the system to perform unexpected reboots or give intermittent, otherwise unexplained errors. Calculate the total wattage requirements of all devices drawing power from the power supply and compare it to the rated capacity of the power supply.

Wattage is calculated as volts $\times$ amps. The power supply is rated in watts, and it should run at about 60% its rated capacity or less. When operating at this capacity, the power supply lasts

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longer, runs cooler, and provides more consistent (or cleaner) power. In most cases, the computer's power supply is more than adequate if you add only one or two new devices. A project at the end of this chapter gives you practice calculating total wattage needs of a computer system. Upgrade the power supply as needed to accommodate an overloaded power system.

If these suggestions don't correct the problem, check the power supply by measuring the voltage output or by exchanging it for one you know is good. Remember that the power supply might give correct voltages when you measure it, but still be the source of problems.

An electrical conditioner might solve the problem of intermittent errors caused by noise in the power line to the PC. Try installing an electrical conditioner to monitor and condition the voltage to the PC. Conditioners are discussed later in the chapter.

The fan on the power supply stops working Usually just before a fan stops working, it hums or whines, especially when the PC is first turned on. If this has just happened, replace the fan if you are trained to service the power supply. If not, then replace the entire power supply, which is considered an FRU (field replaceable unit) for a PC support technician. If you replace the power supply or fan and the fan still does not work, the problem might not be the fan. The problem might be caused by a short somewhere else in the system drawing too much power. Don't operate the PC with the fan not working. Computers without cooling fans can quickly overheat and damage chips.

Turn the power off and remove all power cord connections to all components, including the connections to the system board, and all power cords to drives. Turn the power back on. If the fan comes on, the problem is with one of the systems you disconnected, not with the power supply or its fan.

Turn the power off and reconnect the power cords to the drives. If the fan comes on, you can eliminate the drives as the problem. If the fan does not come on, try one drive after another until you identify the drive with the short.

If the drives are not the problem, suspect the system board subsystem. With the power off, reconnect all power cords to the drives.

Turn the power off and remove the power to the system board by disconnecting P8 and P9 or P1. Turn the power back on.

If the fan comes back on, the problem is probably not the power supply, but a short in one of the components powered by the power cords to the system board. The power to the system board also powers interface cards.

Remove all interface cards and reconnect plugs to the system board.

If the fan still works, the problem is with one of the interface cards. If the fan does not work, the problem is with the system board or something still connected to it.

The system board, just as all other components inside the computer case, should be grounded to the chassis. Look for a metal screw that grounds the board to the computer case. However, a short might be the problem with the electrical system if some component on the board is

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making improper contact with the chassis. This short can cause serious damage to the system board. Check for missing standoffs (small plastic or metal spacers that hold the system board a short distance away from the chassis), the problem that most often causes these improper connections.

Shorts in the circuits on the system board might also cause the problem. Look for damage on the bottom side of the system board. These circuits are coated with plastic, and quite often damage is difficult to spot.

Frayed wires on cable connections can also cause shorts. Disconnect hard drive cables connected directly to the system board. Power up with P8 and P9 or P1 connected, but all cables disconnected from the system board. If the fan comes on, the problem is with one of the systems you disconnected.

TIP

Never replace a damaged system board with a good one without first testing the power supply. You don't want to subject another good board to possible damage.

Upgrading the Power Supply

If you are installing a hard drive or CD-ROM drive and are concerned that the power supply is not adequate, test it after you finish the installation. Make both the new drive and the floppy drive work at the same time by copying files from one to the other. If the new drive and the floppy drive each work independently, but data errors occur when both are working at the same time, suspect a shortage of electrical power.

If you prefer a more technical approach, you can estimate how much total wattage your system needs by calculating the watts for each circuit and adding them together as discussed earlier. In most cases, the computer's power supply is more than adequate if you add only one or two new devices.

Power supplies can be purchased separately. Power supplies for microcomputers range from 200 watts for a small desktop computer system to 600 watts for a tower floor model that uses a large amount of multimedia or other power-hungry devices.

Installing a New Power Supply

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The easiest way to fix a power supply you suspect is faulty is to replace it. You can determine if the power supply really is the problem by turning off the PC, opening the computer case, and setting the new power supply on top of the old one. Disconnect the old power supply's cords and plug the PC devices into the new power supply. Turn on the PC and verify that the new power supply solves your problem before installing it.

If a new power supply is needed, follow these procedures:

1. Turn off the power.
2. Remove all external power cables from the power supply connections.

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3. Remove the cover.
4. Disconnect all power cords from the power supply to other devices.
5. Determine which components must be removed before the power supply can be safely removed from the case. You might need to remove the hard drive, several cards, or the CD-ROM drive. In some cases, you may even need to remove the system board.
6. Remove all the components necessary to get to the power supply. Remember to protect the components from static electricity, as described in Chapter 8.
7. Unscrew the screws on the back of the computer case that hold the power supply to the case.
8. Look on the bottom of the case for slots that are holding the power supply in position. Often the power supply must be shifted in one direction to free it from the slots.
9. Remove the power supply.
10. Place the new power supply into position, sliding it into the slots used by the old power supply.
11. Replace the power supply screws.
12. Replace all other components.
13. Before replacing the case cover, connect the power cords, turn on the PC, and verify that all is working.
14. Test the voltage output of the new power supply and verify that it falls within acceptable ranges.
15. Turn off the PC and replace the cover.

ENERGY STAR COMPUTERS (THE GREEN STAR)

Energy Star computers and peripherals have the U.S. Green Star, which indicates that they satisfy certain energy-conserving standards of the U.S. Environmental Protection Agency (EPA). Devices that can carry the Green Star are computers, monitors, printers, copiers, and fax machines. Such devices are designed to decrease the overall consumption of electricity in the U.S. to protect and preserve our natural resources. These standards, sometimes called the **Green Standards**, generally mean that the computer or the device has a standby program switches the device to sleep mode when it is not being used. During **sleep mode**, the device must use no more than 30 watts of power.

Office equipment is among the fastest growing source of power consumption in industrialized nations. Much of this electricity is wasted, because computers and other equipment are often left on overnight. Because Energy Star devices go into sleep mode when they are unused, they create an overall energy savings of about 50%.

Energy Star PCs

Computer systems use three power management methods to conserve energy:

- Advanced Power Management (APM), championed by Intel and Microsoft
- AT Attachment (ATA) for IDE drives
- Display Power Management Signaling (DPMS) standards for monitors and video cards

These energy-saving features are designed to work in incremental steps, depending on how long the PC is idle. The features can sometimes be enabled and adjusted using CMOS setup or using the OS. In CMOS setup, a feature might not be available, setup might include additional features, or a feature might be labeled differently from those described below.

Green Timer on the System Board

This sets the number of minutes of inactivity that must pass before the CPU goes into sleep mode. You can enable or disable the setting and select the elapse time in number of minutes.

Doze Time

Doze time is the time that elapses before the system reduces 80% of its power consumption. This is accomplished in different ways by different systems. For example, when one system enters Doze mode, the system BIOS slows down the bus clock speed.

Standby Time

The time before the system reduces 92% of its power consumption is **Standby time**. For example, a system might accomplish this by changing the system speed from turbo to slow and suspending the video signal.

Suspend Time

The time before the system reduces 99% of its power consumption is **Suspend time**. The way this reduction is accomplished varies. The CPU clock might be stopped and the video signal suspended. After entering suspend mode, the system needs a warmup time so that the CPU, monitor, and other components can reach full activity.

Hard Drive Standby Time

Hard drive standby time is the amount of time before a hard drive shuts down.

Sample Power Management Setup Screen

Figure 11-13 shows the Power Management Setup screen of the CMOS setup for Award BIOS for an ATX Pentium II system board. Using the Video options on the left of the screen, you can enable or disable power management of the monitor. When power management is enabled, you can control Energy Star features. The PM Timers feature controls doze, standby, and suspend modes for the hard drive. The Power Up Control determines the way

the system can be controlled when it is started or when power to the computer is interrupted. The features on the right side of the screen monitor the power supply fan, CPU fan, optional chassis fan, temperatures of the CPU and the motherboard (MB), and voltage output to the CPU and system board.

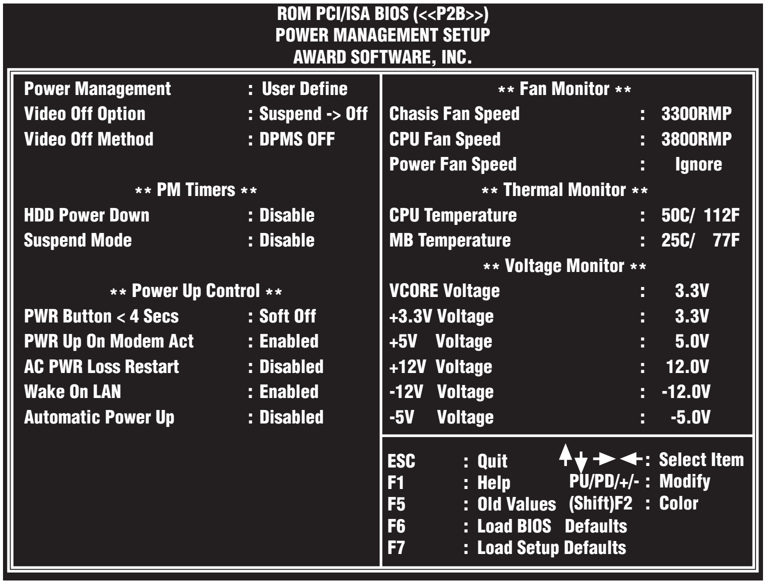

Figure 11-13 A Power Management Setup screen showing power management features

Energy Star Monitors

Most computers and monitors sold today are Energy-Star-compliant, displaying the green Energy Star logo onscreen when the PC is booting.

In order for a monitor's power-saving feature to function, the video card or computer must also support this function. Most monitors that follow the Energy Star standards adhere to the **Display Power Management Signaling** (**DPMS**) specifications developed by VESA, which allow for the video card and monitor to go into sleep mode simultaneously.

Windows 9x sometimes recognizes that a monitor is an Energy Star monitor by its brand and model. To see if Windows 95 has identified a monitor as Energy-Star-compliant, open the **Display Properties** dialog box. One way to do this is to right-click anywhere on the desktop and select **Properties** from the shortcut menu. In the Display Properties dialog box, click the **Settings** tab, and then select **Change Display Type** (or, for OSR 2, select **Advanced Properties**). The Change Display Type dialog box opens, as shown in Figure 11-14. If you know that your monitor is Energy-Star-compliant, check the appropriate box. For Windows 98, right-click the desktop, select **Properties** from the shortcut menu, click the **Settings** tab and click **Advanced**. The monitor Properties dialog box opens. Click the Monitor tab and the dialog box in Figure 11-15 is displayed showing the Energy Star check box.

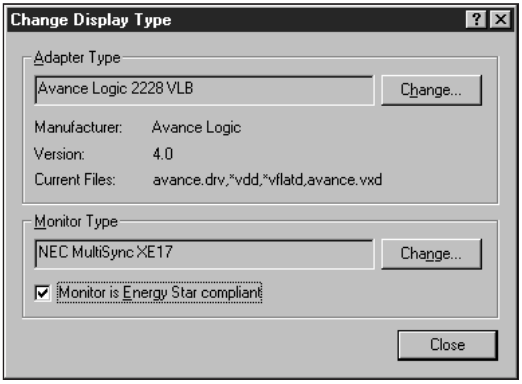

Figure 11-14 Windows 95 setting for an Energy Star monitor

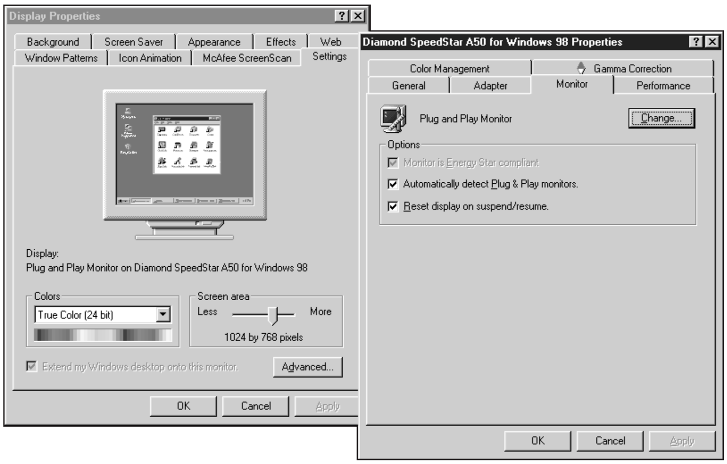

Figure 11-15 In Windows 98, the Energy Star check box is grayed for this monitor and cannot be unchecked

To use the Energy Star features of your monitor, click the **Screen Saver** tab in the **Properties** dialog box to open the dialog box shown in Figure 11-16. Click the **Settings** button of the Energy savings feature. You can set system standby to activate after a specified number of minutes. Select the minutes under **Turn off monitor**. This feature causes your Energy Star monitor to go into sleep mode. Some monitors have an additional feature that allows the PC to shut off the monitor after a selected number of minutes of inactivity. Read the documentation that comes with the monitor to learn what features a monitor has and how to use them.

TIP

Problems might occur if CMOS is turning off the monitor because of power management settings and Windows 9x is also turning off the monitor. If the system hangs when you try to get the monitor going again, try disabling one or the other.

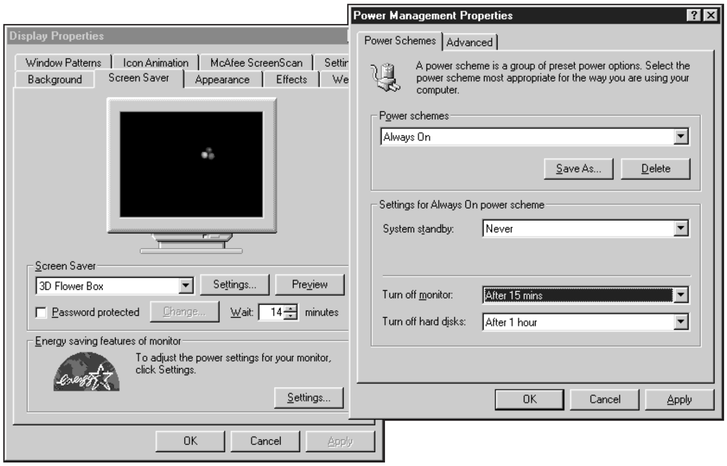

Figure 11-16 Using the monitor's Energy Star features

Surge Protection and Battery Backup

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A wide range of devices on the market filter the AC input to computers and their peripherals (that is, condition the AC input to eliminate highs and lows) and that provide backup power when the AC current fails. These devices, installed between the house current and the computer, fall into three general categories: surge suppressors, power conditioners, and uninterruptible power supplies (UPSs). All these devices should have the UL (Underwriters Laboratory) logo, which ensures that the device has been tested by this agency, a provider of product safety certification.

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Surge Suppressors

A **surge suppressor**, also called a **surge protector**, provides a row of power outlets and an on/off switch that protects equipment from overvoltages on AC power lines and telephone lines. Surge suppressors can come as power strips, as seen in Figure 11-17 (but not all power strips have surge protection), wall-mounted units that plug into AC outlets, or consoles designed to sit on a desk top (Figure 11-18) with the monitor placed on top. Some provide an RJ-11 telephone jack to protect modems and fax machines from spikes.

TIP

Whenever there is a power outage, unless you have a reliable power conditioner or UPS installed, unplug all power cords to the PC, printers, monitors, and the like. Sometimes when the power returns there are sudden spikes accompanied by another brief outage. You don't want to subject your equipment to these surges.

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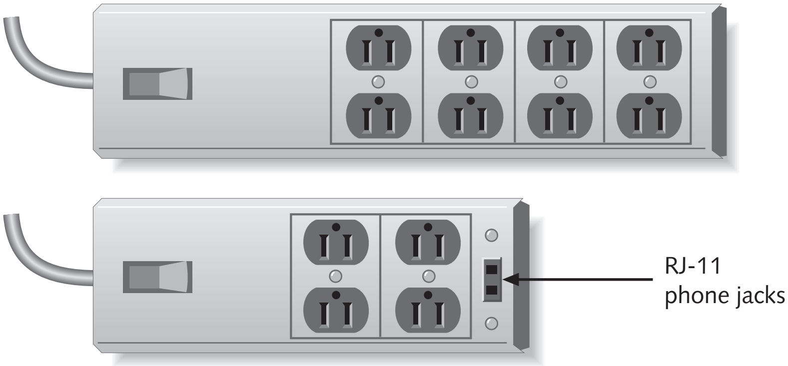

Figure 11-17 A surge suppressor can protect a device against overvoltage or spikes

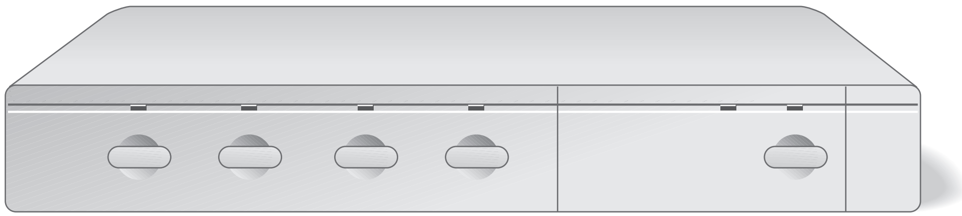

Figure 11-18 A surge suppressor might be designed to sit underneath the monitor on the desk top

Surge suppressors are not always reliable, and once the fuse inside the suppressor is blown, a surge suppressor no longer protects from a power surge. It continues to provide power without warning you that the protection is lost. The performance of a surge suppressor as protection against spikes is measured in two ways: let-through voltage and joules.

The maximum voltage that is allowed through the suppressor to the device being protected is called the **let-through**. Less is better. The better units are expected to let through under 330 volts. Less expensive suppressors let through 400 volts or more.

The degree of protection of a surge suppressor can be measured in **joules**, a measure of energy that takes into account both voltage and current over a one-second interval. More is better. Look for devices that offer at least 240 joules of protection.

A surge suppressor might be a shunt type that absorbs the surge or might be a series type that blocks the surge from flowing, or it might be a combination of the two. The shunt-type suppressor is measured by **clamping voltage**, a term that describes the let-through voltage.

When buying a surge suppressor, look for those that guarantee against damage from lightning and that reimburse for equipment destroyed while the surge suppressor is in use.

Data Line Protectors

A **data line protector** serves the same function for your telephone line to your modem that a surge suppressor does for the electrical lines. Telephone lines carry a small current of

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electricity and need to be protected against spikes, just as electrical lines do. The let-through rating for a data line protector for a phone line should be no more than 260 volts.

Measuring Power Ranges of Devices

The next two types of protective devices are power conditioners and uninterruptible power supplies. They both condition (alter so as to provide continuous voltages) the power passing through them. Both provide a degree of protection against spikes (temporary surges of voltage) and raise the voltage when it drops during brownouts (temporary reductions of voltage). These devices are measured by the load they support in watts, volt-amperes (VA), or kilo-volt-amperes (kVA).

To determine how much VA is required to support your system, multiply the amperage of each component by 120 volts and then add up the VA for all components. For example, a 17-inch monitor has 1.9 A written on the back of the monitor, which means 1.9 amps. Multiply that value times 120 volts and you see that 228 VA is required. A Pentium PC with a 17-inch monitor and tape backup system requires about 500 VA of support.

Power Conditioners

In addition to providing protection against spikes, **power conditioners** also regulate, or condition, the power, providing continuous voltage during brownouts. These voltage regulators, sometimes called **line conditioners**, can come as small desktop units (see Figure 11-19).

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Low-cost line conditioners use a stepped transformer to adjust the output voltage. Higher priced models use a **ferroresonant regulator**, which contains a magnetic coil that can retain a charge of power to be used to raise the voltage during a brownout.

These electricity filters are a good investment if the AC current in your community suffers from excessive spikes and brownouts. However, if the device is rated under 1 kVA, it will probably only provide corrections for brownouts, and not spikes. Line conditioners, like surge suppressors, provide no protection against a total blackout.

Figure 11-19 A power conditioner can protect a device against overvoltage (spikes) and provide continuous voltage during brownouts

Uninterruptible Power Supply

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Unlike a power conditioner, the **UPS (uninterruptible power supply)** provides a backup power supply in the event the AC current fails completely. The UPS also offers some filtering of the AC current. A UPS device suitably priced for personal computer systems is designed as either a standby device, an inline device, or a line-interactive device (which combines features of the first two). Among these three UPS devices, there are several variations on the market, whose prices vary widely.

A common UPS device is a rather heavy box that plugs into an AC outlet and provides one or more outlets for the computer and its peripherals (see Figure 11-20). It has an on/off switch, requires no maintenance, and is very simple to install.

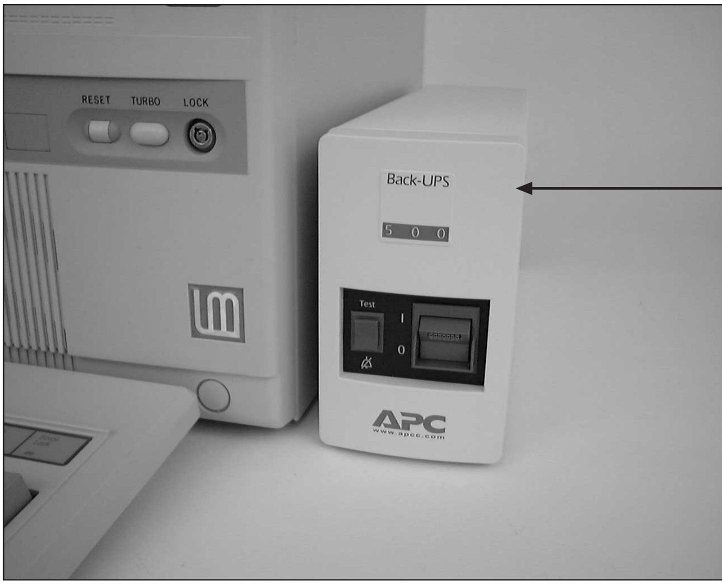

Figure 11-20 Uninterruptible power supply (UPS)

Standby and inline UPSs differ in the circuit the devices use as the primary circuit, and in the way they function when the AC power fails. A **standby UPS** switches circuits from the AC circuit to the battery-powered circuit. In contrast, the **inline UPS** continually provides power through the battery-powered circuit and therefore requires no switching, which ensures continuous power.

UPS prices increase dramatically depending on the features offered. A UPS device is rated according to the amount of power it can provide, in VA during a complete blackout, and the length of time it can sustain that power. Most UPSs for microcomputer systems claim to provide backup power for only about 15 minutes, only enough time to save any work in progress and to do an orderly shutdown. The high cost of a UPS prohibits greater power.

The Standby UPS

Figure 11-21 shows how UPSs work. The solid line represents the primary circuit by which electricity normally flows. The dashed line represents the secondary circuit that is used when the AC current fails. For the standby UPS, the primary circuit is the house AC current circuit with an inline surge suppressor and filter. A relatively small amount of the current flows to the secondary circuit to keep the battery charged in case it is ever needed. When the AC current fails, the UPS switches from the primary to the secondary circuit and the battery provides the power, which is converted from DC to AC before it leaves the UPS.

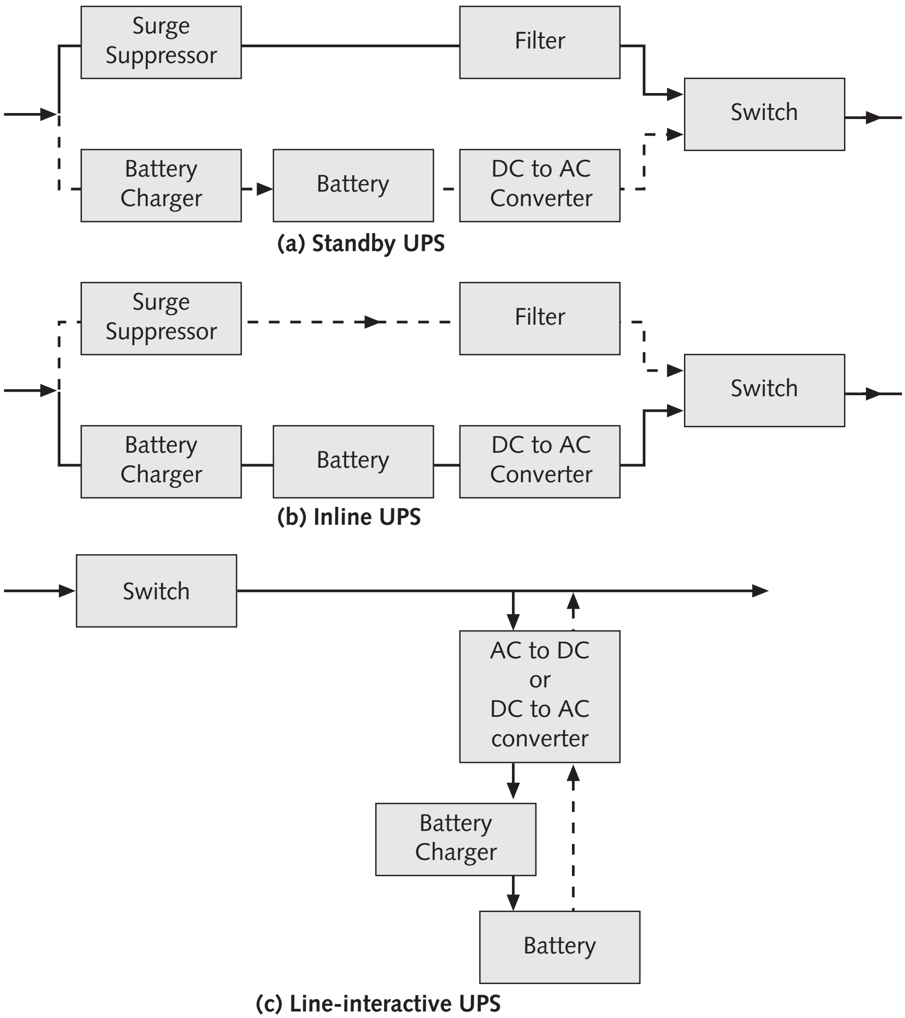

Figure 11-21 Standby, In-line, or Line-interactive UPS

The switching time (the time it takes for the UPS to switch from the AC circuit to the battery-charged circuit) caused problems for earlier computers, even causing the PC to reboot.

Today, however, computer power supplies are better designed and able to keep the computer running during the fraction of a second it takes to switch the power in the UPS. One variation on a standby UPS uses a ferroresonant regulator that delivers power to the circuit during the switching time, to virtually eliminate any interruption of power.

Other variations of this type of UPS reduce costs by eliminating the filter. The purpose of the filter is to condition the AC current, reducing the effect of brownouts and spikes. These electricity filters, or line conditioners, must be purchased separately.

The Inline UPS

In Figure 11-21, notice that the inline UPS uses the battery-powered circuit as the primary circuit, instead of the AC circuit. With most devices, the AC circuit is only used if the battery-powered circuit registers any error conditions caused by the failure of some component in the circuit. These conditions are not related to spikes, brownouts, or blackouts of the AC current, but rather to the performance of the components. With some inline UPS devices, both circuits are continuously used to collectively provide power.

With inline UPSs, when the AC current fails, no switching is needed because the primary circuit continues to be the battery-powered circuit. The only thing that is lost is the battery's recharging. These UPS devices are sometimes called true UPSs, because they truly do provide uninterruptible power.

The inline UPS also provides more line conditioning than does the standby UPS, and, because of the clean, constant 120-volt current it produces, it can extend the life of computer equipment. Because the inline UPS converts the AC power to battery power in DC and then back to AC power, the inline design is sometimes referred to as **double conversion**. Because the battery is in constant use, the inline UPS battery tends to wear out sooner than does the standby UPS battery.

The inline UPS is more expensive than the standby UPS; one less expensive variation eliminates the secondary circuit altogether, leaving the battery-charged circuit with no backup.

The Line-Interactive UPS

The **line-interactive UPS** is a variation of the standby UPS that shortens the switching time by always keeping the inverter working, so that there is no charging-up time for the inverter. An inverter is a device that converts DC to AC. However, during regular operation, the inverter filters electricity and charges the battery by converting AC to DC. See Figure 11-21c. If the power fails, the switch breaks the normal circuit and the inverter switches roles and begins to convert the battery's DC to AC. The delay for the inverter to switch roles is shorter than the delay for a standby UPS that must start up the inverter.

The line-interactive UPS also offers good line conditioning because there is an automatic voltage regulator, called the **buck-boost** feature. During spikes in electrical power, the regulator decreases (in other words bucks) the voltage, and it boosts it during brownouts. The boost feature means that the line-interactive UPS does not need to draw on battery power to respond to a brownout, as does the true standby UPS.

The Intelligent UPS

Some UPSs can be controlled by software from a computer, to allow for additional functionality. For example, from the front panel of some UPSs you can check for a weak battery. If the UPS is an **intelligent UPS**, you can perform the same function from the utility software installed on your computer. In order for a UPS to accommodate this feature, it must have a serial port connection to the PC and a microprocessor on board. Some of the things this utility software and an intelligent UPS can do are:

- Diagnose the UPS
- Check for a weak battery
- Monitor the quality of electricity received
- Monitor the percentage of load the UPS is carrying during a blackout
- Automatically schedule the weak-battery test or UPS diagnostic test
- Send an alarm to workstations on a network to prepare for a shutdown
- Close down all servers protected by the UPS during a blackout
- Provide pager notification to a facilities manager if the power goes out during weekends
- After a shutdown, allow for startup from a remote location over phone lines

Windows NT and Windows 2000 offer support for intelligent UPSs. You can monitor and control the devices from the UPS dialog box accessible through Control Panel. The Windows 2000 controls were developed by Microsoft and Amercian Power Conversion (APC), a leading manufacturer of UPSs.

When Buying a UPS

The power supplies in most computers can operate over a wide range of electrical voltage input, but operating the computer under these conditions for extended periods of time can shorten the life not only of the power supply, but also of the computer as well. Power protection devices offer these benefits:

- Condition the line for both brownouts and spikes
- Provide backup power during a blackout
- Protect against very high spikes that could damage the equipment

When you purchase a UPS, cost often drives the decision about how much and what kind of protection you buy. However, do not buy an inline UPS that runs at full capacity. A battery charger operating at full capacity produces heat, which can reduce the life of the battery. The UPS rating should exceed your total VA or wattage output by at least 25 percent. Also be aware of the degree of line conditioning that the UPS provides. Consider the warranty and service policies as well as the guarantee the UPS manufacturer gives for the equipment that the UPS protects.

Fire Extinguishers

A+CORE 3.2

No discussion of working on electrical equipment would be complete without mentioning the importance of having a fire extinguisher handy that is rated to handle fires that are ignited by electricity. The National Fire Protection Association (NFPA), an organization that creates standards for fire safety, says a fire has one of three ratings.

- ***Class A.*** A fire that is fueled by ordinary combustible materials such as wood, trash, or clothes
- ***Class B.*** A fire that is fueled by flammable liquids such as oil, gasoline, kerosene, propane gas, and some plastics
- ***Class C.*** A fire that is ignited and heated by electricity

It's the Class C fire that we are concerned about in this discussion. For a fire to be rated as a Class C fire, regardless of what is burning, the fire must have been ignited by electricity and must keep burning because electrical energy is providing heat. If you take away the electrical current, then the fire becomes a Class A or Class B fire.

Underwriters Laboratories (UL) rates fire extinguishers according to the type of fire they handle and the size of fire they can put out. Ratings are usually displayed on the extinguisher as an icon. (See Figure 11-22.) The class letter is inside a triangle for Class A, a square for Class B, and a circle for Class C. The extinguisher can be rated for more than one type of fire and includes a number for Class A and B fires that indicate what size fire it can handle. A Class C rating is not assigned a number because the size of the fire is determined more by the A or B fuel type. Class A ratings are from 1 to 40 and Class B ratings are from 1 to 640. An excellent choice for a fire extinguisher for home use is one that carries all three ratings. A good example is one rated as 2-A: 10-B: C. This means the extinguisher can handle Class A fires of magnitude 2 on a scale of 1 to 40, Class B fires of magnitude 10 on a scale of 1 to 640, and can handle Class C fires. Fire extinguishers come as either disposable or rechargeable. The rechargeable ones cost more but can be recharged and last longer. Disposable ones lose their pressure after about 12 years and must be replaced.

Mount the fire extinguisher near your workbench but not directly over your work area. If equipment were to catch on fire, you wouldn't want to have to reach over it to get to the fire extinguisher. Know how to use the extinguisher. One good method to remember is the **P-A-S-S** method (**P**ull the pin, **A**im low at the base of the fire, **S**queeze the handle of the extinguisher, and **S**weep back and forth across the base of the fire).

Large computer facilities might have a built-in halon gas system to extinguish fires. Halon does not damage equipment as much as do other types of fire extinguisher chemicals; however, halon is considered an environmental hazard. In 1987, an international agreement, known as the Montreal Protocol, mandated the phaseout of halon fire extinguishing systems in developed countries by the year 2000 and in less-developed countries by 2010, because of the danger halon poses to the ozone layer.

Figure 11-22 A fire extinguisher is rated by Underwriters Laboratories. Look for a Class C rating to handle fires ignited by electrical current

Chapter Summary

- Electricity describes the components necessary for a complete circuit. An electrical circuit is created by a combination of voltage, current, and resistance.
- Electrical voltage is a measure of the potential difference in an electrical system.
- Electrical current is measured in amps, and electrical resistance is measured in ohms. One volt drives a current of one amp through a resistance of one ohm, which is one watt of power.
- Wattage is a measure of electrical power. Wattage is calculated by multiplying volts by amps in a system.

- Microcomputers require DC current, which is converted from AC current by the PC's power supply inside the computer case.
- A PC power supply is actually a transformer and rectifier rather than a supplier of power.
- A multimeter is a device that can measure volts, amps, ohms, and continuity in an electrical system.
- Before replacing a damaged system board in a PC, first measure the output of the power supply to make sure that it did not cause the damage.
- A faulty power supply can cause memory errors, data errors, system hangs, or reboots, and it can damage a system board or other component.
- The U.S. Environmental Protection Agency has established Energy Star standards for electronic devices, to reduce energy consumption.
- Devices that are Energy-Star-compliant go into a sleep mode in which they use less than 30 watts of power.
- PCs that are Energy-Star-compliant often have CMOS settings that affect the Energy Star options available on the PC.
- Devices that control the electricity to a computer include surge suppressors, line conditioners, and UPSs.
- A surge suppressor protects a computer against damaging spikes in the electrical voltage.
- Line conditioners level out the AC current to reduce brownouts and spikes.
- A UPS provides enough power to perform an orderly shutdown during a blackout.
- There are two kinds of UPSs: the true UPS, called the inline UPS (or, sometimes, the online UPS) and the standby UPS.
- The inline UPS is the more expensive, because it provides continuous power. The standby UPS must switch from one circuit to another when a blackout begins.
- An intelligent UPS can be controlled and managed from utility software at a remote computer, or from a computer connected to the UPS through a serial cable.
- Data line protectors are small surge suppressors designed to protect modems from spikes on telephone lines.
- A Class C fire extinguisher is rated to put out a fire ignited and kept burning by electricity.

KEY TERMS

Alternating current (AC) — Current that cycles back and forth rather than traveling in only one direction. In the U. S., the AC voltage from a standard wall outlet is normally between 110 and 115 V AC. In Europe, the standard AC voltage from a wall outlet is 220 V AC.

Ammeter — A meter that measures electrical current in amps.

Ampere (A) — A unit of measurement for electrical current. One volt across a resistance of one ohm will produce a flow of one amp.

Autorange meter — A multimeter that senses the quantity of input and sets the range accordingly.

Buck-boost regulator — A line-interactive UPS that offers good line conditioning and has an automatic voltage regulator that decreases ("bucks") the voltage during electrical spikes and boosts it during sags.

Capacitor — An electronic device that can maintain an electrical charge for a period of time and is used to smooth out the flow of electrical current. Capacitors are often found in computer power supplies.

Clamping voltage — The maximum voltage allowed through a surge suppressor, such as 175 or 330 volts.

Continuity — A continuous, unbroken path for the flow of electricity. A continuity test can determine whether or not internal wiring is still intact or a fuse is good or bad.

Data line protectors — Surge protectors designed to work with the telephone line to a modem.

Diode — An electronic device that allows electricity to flow in only one direction. Used in a rectifier circuit.

Direct current (DC) — Current that travels in only one direction (the type of electricity provided by batteries). Computer power supplies transform AC current to low DC current.

Display power management signaling (DPMS) — Energy Star standard specifications that allow for the video card and monitor to go into sleep mode simultaneously. *See* Energy Star systems.

Double conversion — The process by which the inline UPS converts the AC power to battery power in DC form and then back to AC power.

Doze time — The time before an Energy Star or "Green" system will reduce 80% of its activity.

EMI (**electromagnetic interference**) — A magnetic field produced as a side effect from the flow of electricity. EMI can cause corrupted data in data lines that are not properly shielded.

Energy Star systems — "Green" systems that satisfy the EPA requirements to decrease the overall consumption of electricity. *See* Green standards.

Ferroresonant regulator — A UPS device that contains a magnetic coil that can retain a power charge that can be used during a brownout to raise the voltage at switching time.

Green Standards — Standards that mean that a computer or device can go into sleep or doze mode when not in use, thus saving energy and helping the environment.

Hard drive standby time — The amount of time before a hard drive will shut down to conserve energy.

Inline UPS — A UPS that continually provides power through a battery-powered circuit, and, because it requires no switching, ensures continuous power to the user.

Intelligent UPS — A UPS connected to a computer by way of a serial cable so that software on the computer can monitor and control the UPS.

Joule — A measure of energy equal to the work done when a current of one ampere is passed through a resistance of one ohm for one second.

Let-through — The maximum voltage allowed through a surge suppressor to the device being protected.

Line conditioners — Devices that regulate, or condition the power, providing continuous voltage during brownouts and spikes.

Line-interactive UPS — A variation of a standby UPS that shortens switching time by always keeping the inverter that converts AC to DC working, so that there is no charge-up time for the inverter.

Multimeter — A device used to measure the various components of an electrical circuit. The most common measurements are voltage, current, and ohms.

Ohms — The standard unit of measurement for electrical resistance. Resistors are rated in ohms.

P-A-S-S — An acronym to help remember how to use a fire extinguisher. (Pull the pin, Aim low at the base of the fire, Squeeze the handle of the extinguisher, and Sweep back and forth across the fire.)

Power conditioners — Line conditioners that regulate, or condition, the power, providing continuous voltage during brownouts.

Rectifier — An electrical device that converts AC to DC. A PC power supply contains a rectifier.

Resistance — The degree to which a device opposes or resists the flow of electricity. As the electrical resistance increases, the current decreases. *See* Ohms and Resistor.

Resistor — An electronic device that resists or opposes the flow of electricity. A resistor can be used to reduce the amount of electricity being supplied to an electronic component.

Sleep mode — A mode used in many "Green" systems that allows them to be configured through CMOS to suspend the monitor or even the drive, if the keyboard and/or CPU have been inactive for a set number of minutes. *See* Green standards.

Standby time — The time before a "Green" system will reduce 92% of its activity. *See* Green standards.

Standby UPS — A UPS that quickly switches from an AC power source to a battery-powered source during a brownout or power outage.

Surge suppressor or **surge protector** — A device or power strip designed to protect electronic equipment from power surges and spikes.

Suspend time — The time before a green system will reduce 99% of its activity. After this time, the system needs a warmup time so that the CPU, monitor, and hard drive can reach full activity.

Transformer — A device that changes the ratio of current to voltage. A computer power supply is basically a transformer and a rectifier.

Transistor — An electronic device that can regulate electricity and act as a logical gate or switch for an electrical signal.

UPS (uninterruptible power supply) — A device designed to provide a backup power supply during a power failure. Basically, a UPS is a battery backup system with an ultra-fast sensing device.

Volt — A measure of potential difference in an electrical circuit. A computer ATX power supply usually provides five separate voltages: +12V, –12V, +5V, –5V, and +3V.

Voltage — Electrical differential that causes current to flow, measured in volts. *See* Volts.

Voltmeter — A device for measuring electrical AC or DC voltage.

Wattage — Electrical power measured in watts.

Watts — The unit used to measure power. A typical computer may use a power supply that provides 200 watts.

Review Questions

1. Describe three similarities a closed-circuit water system has with a closed-circuit electrical system.
2. Volts are a measure of what characteristic of electricity?
3. What is the normal voltage of house current in the U.S.?
4. Why must an ammeter be installed in line with the circuit in order to measure amps?
5. Which of the three can be measured with the power off, volts, amps, or ohms? Why?
6. Describe the relationship between volts, amps, and ohms in a circuit.
7. What are the five voltages produced by an ATX power supply?
8. What are the four voltages produced by an AT power supply?
9. What is the wattage of a current of 15 amps and a voltage of 120 volts?
10. What is the difference between a transformer and a rectifier? Which are found in a PC power supply?
11. Describe the purpose of the ground line in a house circuit. Show the electrical symbol for ground.
12. What is the basic electronic building block of an integrated circuit?
13. Why is a power supply dangerous even after the power is disconnected?
14. What is the symbol for a diode?
15. What is a simple way to detect EMI?
16. What is a closed connection between two points in a circuit called?
17. What DVM setting do you use to determine if a fuse is good?
18. What DVM voltage range do you use to measure house current voltage, 110V or 120V? Why?
19. With the PC power turned on, if you have set a DVM to measure voltage and place one probe on a ground lead of a hard drive power connection and the other probe on the computer case, what will be the voltage reading?
20. List four computer symptoms that indicate a faulty power supply.
21. If you measure the voltage of a power supply and find it to be within acceptable ranges, why is it still possible that the power supply may be faulty?
22. How much power can a device use in sleep mode if it complies with Green Standards?

23. Name one thing that can be set in CMOS that pertains to power management.
24. How can you easily tell if a computer is designed to comply with Green Standards?
25. Name two ways that a surge suppressor is measured.
26. Using a multimeter, what will be the measurement in ohms of a good fuse?
27. What are the two main types of uninterruptible power supplies?
28. How does an intelligent UPS differ from one that is not intelligent?
29. What class fire extinguisher is used for electrical fires?
30. What does the term PASS mean when you are using a fire extinguisher?

PROJECTS

Hands-on Project

Energy Star Features on a PC

Write down each of the power management and Energy Star features that can be set through CMOS on your home or lab computer.

Hands-on Project

Price and Value Comparisons

At your local computer vendor(s), compare the prices and ratings of two different surge suppressors.

Hands-on Project

PC Power Supply Facts

Remove the cover from your home or lab PC and answer the following questions:

1. How many watts are supplied by your power supply? (It is usually printed on the label on the top of the power supply.)
2. How many cables are supplied by your power supply?
3. Where does each cable lead?
4. Is there a switch on the back of the power supply that can be set for 220 volts (Europe) or 110 volts (U.S.)?

Hands-on Project

Build a Circuit to Turn on a Light

1. From the following components, build a circuit to turn on a light:
   - An AC light bulb or LED (*Note*: A LED has polarity—it must be connected with the negative and positive terminals in the correct positions.)
   - A double-A battery (*Note*: A 9-volt battery can cause some bulbs to blow up.)
   - A switch (A knife switch or even a DIP switch will work.)
   - Three pieces of wire to connect the light, the switch, and the battery
2. Add a second battery to the circuit and record the results.
3. Add a resistor to the circuit and record the results.
4. Place an extra wire in the middle of the circuit running from the battery to the switch (thus making a short) and record the results.

Measure the Output of Your Power Supply

Measure the power output to the system board of your computer and to the floppy drive. Fill in the following chart. Note that red and black leads refer to the color of the probes.

AT System Board

Red Lead	Black Lead	Voltage Measure
3	5	
3	6	
3	7	
3	8	
4	Ground	
9	Ground	
10	Ground	
11	Ground	
12	Ground	

ATX System Board

Red Lead	Black Lead	Voltage Measure
1	4	
1	6	
1	8	
1	14	
1	15	
1	16	
1	18	
2	Ground	
5	Ground	
7	Ground	
9	Ground	
10	Ground	
11	Ground	
12	Ground	
13	Ground	
19	Ground	
20	Ground	

Floppy Drive

Red Lead	Black Lead	Voltage Measure
1	3	
4	2	

Research the Market for a UPS for Your Computer System

For a computer system you have access to, determine how much wattage output a UPS should have in the event of a total blackout, and estimate how long the UPS should sustain the power. Research the market and report on the features and prices of a standby UPS and an inline UPS. Include the following information in your report:

- Wattage supported
- Length of time the power is sustained during total blackout
- Line-conditioning features
- AC backup present or not present for the inline UPS
- Ferroresonant transformer present or not present
- Surge suppressor present or not present
- Number of power outlets on the box and other features
- Written guarantees
- Brand name, model, vendor, and price of the device

Using a Multimeter in Troubleshooting

A user comes to you with a problem. He has a cable that connects the serial port of his computer to a serial printer. He needs to order more of the same cables, but he does not know whether this cable is a regular serial cable or a specialized cable made specifically for this printer. One connector on the cable is 9-pin and the other connector is 25-pin. Use a multimeter measuring continuity to answer these questions.

1. Is this a regular serial cable? (*Hint*: Use your pinout results from the project at the end of Chapter 9, and verify with a multimeter that your expectations are correct.)
2. If this is not a regular serial cable, but a specialized cable, give the user the pinouts necessary to order new custom-made cables.

Detecting EMI

Use a small, inexpensive AM radio. Turn the dial to a low frequency, away from a station. Put the radio next to several electronic devices. List the devices in order, from the one producing most static to the one producing least static. Listen to the devices when they are idle and in use.

Hands-on Project

Total Wattage Used by Your Computer System

Fill in the following chart and then calculate the total wattage requirements of your computer system compared to the rating of your power supply. Include in the chart all devices that draw power from the power supply. Look for a wattage rating printed somewhere on the device.

Component	Wattage	
Hard drive		
Floppy drive		
CD-ROM drive		

Total wattage requirements: ____________

Wattage rating of the power supply: ____________

This power supply is running at ____________ percent of full capacity.